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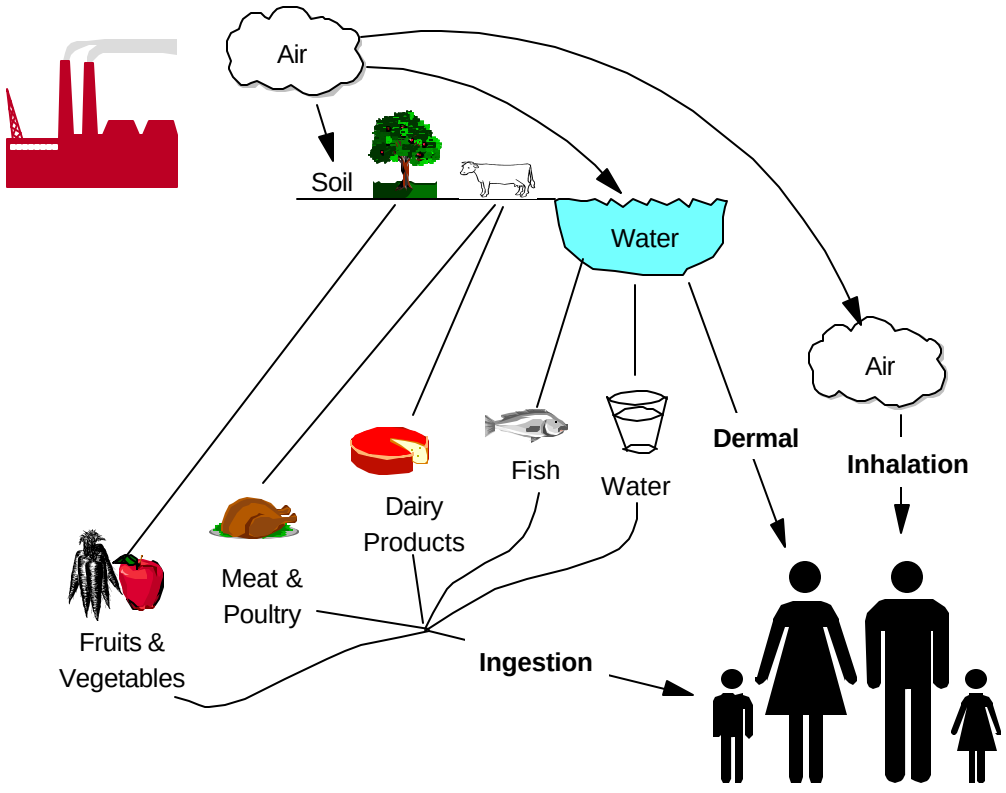
Fact Sheet
Computer Modeling: Exposure Models

What is exposure?

Exposure is the contact between a target organism and a pollutant at the outer boundary of the organism. Exposure may be quantified as the amount of pollutant available at the boundary of the receptor organism per specified time period.

How does exposure occur?

Human exposures to pollutants can result from contact with contaminated air, water, soils, and food, as well as with drugs and consumer products. Exposures may be dominated by contact with a single medium, or concurrent contacts with multiple media may be significant.



People may be exposed to air toxics in ways other than direct inhalation

What key factors determine the level of exposure?

The nature and extent of such exposures depend largely on two things: (1) human factors, and (2) the concentrations of a pollutant in the exposure media. Human factors include all behavioral, sociological, and physiological characteristics of an individual or cohort (that is, a group of people within a population that can be aggregated because the variation in exposure within the group is much less than the group-to-group variation across the population) that directly or indirectly affect a person's contact with the substances of concern. Important behavioral factors are contact rates with food, air, water, and soils. Activity patterns, which are defined by an individual's or cohort's allocation of time spent in different activities at various locations, are also significant because they directly affect the magnitude of exposures to substances present in different indoor and outdoor environments. Information on activity patterns is taken from measured data collected during field and telephone surveys of individuals' daily activities, the amount of time spent engaged in those activities, and the locations where the activities occur.

How do I incorporate an exposure model into my assessment?

An air quality dispersion model predicts an ambient concentration for a given time period at a given location. If a person could remain at this location for the specified time period (the time period associated with the health benchmark of concern), the concentration predicted by the air quality dispersion model would equal his "apparent" exposure, or the concentration available for the subject to breathe. In the real world, people's day-to-day activities generally move them from one geographic location to another (for example, from home to work, or home to school). Also, most people do not spend all of their day outdoors; a majority of our time is spent in indoor locations (for example, home, workplace, school, or vehicle). Studies have shown that air quality concentrations in indoor environments can be quite different from those in the outdoor environment. Because of these factors, an exposure model is generally employed to consider these human factors and predict the "apparent" exposure.

Which exposure model should you choose?

The choice of a model and the way it is applied will depend on numerous factors such as:

- spatial scale (for example, national, regional, or local)
- temporal scale (for example, hourly, daily, or annual)
- type of pollutant (for example, gaseous, particulate, reactive)
- media and pathways (for example, air, water, soil, inhalation, ingestion)
- type of receptors (for example, general public, sensitive populations, terrestrial ecosystems, aquatic ecosystems)

- emission source type (for example, stationary, mobile, elevated, complex terrain)
- availability of input data (for example, meteorological data, census data)
- an acceptable level of uncertainty in the model's results.

By understanding the different features of individual models, you'll be able to select a model or models whose features are most critical to your objective. Even within a model there are modeling options, allowing the model to run in different ways as you choose. For example, you may choose to use default activity diary data and exposure factor distributions contained within the model or you may substitute data distributions that are more appropriate for the population of interest.

Some exposure models include statistical computation routines. They are often referred to as Monte Carlo Simulations due to their random selection of variable values from the activity pattern diaries or exposure factor distributions. Through the completion of hundreds to thousands of iterations, they derive estimated exposure and dose distributions that characterize the range of potential exposures and doses and the impact of uncertainty in the model and its inputs on the results.

What exposure models are available?

Described below are a few exposure models utilized by OAQPS :

- HEM (Human Exposure Model) estimates long-term human health risks from inhalation exposures to individuals and populations. Developed by the Office of Air Quality Planning and Standards (OAQPS), it contains the Industrial Source Complex Long Term Version 2 (ISCLT2) dispersion model with the national set of meteorological files it requires and 1990 block level census data. HEM estimates air concentrations of pollutants at fixed receptors up to 50 kilometers from the source and interpolates the receptor's air concentrations to the population block centroids to estimate the highest exposure and risk, number of individuals exposed to various exposure and risk levels, and cancer incidence.
- HAPEM4 (Hazardous Air Pollutant Exposure Model, Version 4) can estimate human toxic air pollutant inhalation exposures by examining the activity patterns of population groups and by simulating their movements between home and work locations. Using air concentrations supplied by external air dispersion models or monitoring networks, HAPEM4 extracts activity data from the Comprehensive Human Activity Database (CHAD) and estimates annual average inhalation exposure concentrations to specific population groups.
- IEM-2M (Indirect Exposure Model, Version 2) was developed by EPA's Office of Research and Development initially for the dioxin exposure reassessment and revised for the *Mercury Study, Report to Congress*. Most of the equations are documented

in the *Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions (MPE).* IEM-2M is a set of linked Excel® spreadsheets that include mercury-species cycling in the aquatic environment. It has been adapted by EC/R Incorporated (under contract to OAQPS) for additional pollutants. IEM-2M produces point estimates of media concentrations, exposure, and risk from input air toxics air concentrations and deposition rates. It can be used with the Crystal Ball® spreadsheet add-in, and user supplied exposure factor and uncertainty distributions, to develop output distributions reflecting estimates of inter-individual variability and their uncertainty.

- TRIM (Total Risk Integrated Methodology) is a modular computer modeling system being developed by OAQPS to address all dimensions of risk evaluation, including exposure assessment. TRIM will include sophisticated algorithms for assessing chemical fate and transport between environmental compartments, exposure variability and uncertainty, and human and ecological exposures. It will allow for multipathway exposure to pollutants, using a dynamic mass balance approach to estimate the exposure and dose profiles received by selected receptors. TRIM.FaTE, the multimedia fate and transport component is currently being compared to IEM-2M for a small set of air toxics. TRIM.Expo, the exposure component, will be expanded to include pathways beyond inhalation, and together with TRIM.Risk will produce distributions of exposure and risk estimates that account for variability and uncertainty.

Where can you find more information?

It is important to keep in mind that there are many other agency and non-agency exposure models available. A more complete compendium of recent exposure models can be found in the document, "Total Risk Integrated Methodology. TRIM.Expo Technical Support Document. External Review Draft (EPA-453/D-99-001)," which can be found at http://www.epa.gov/ttnatw01/urban/trim/trimpg.html.

For information on obtaining the exposure assessment tools and models described above, contact the Risk and Exposure Assessment Group of OAQPS.